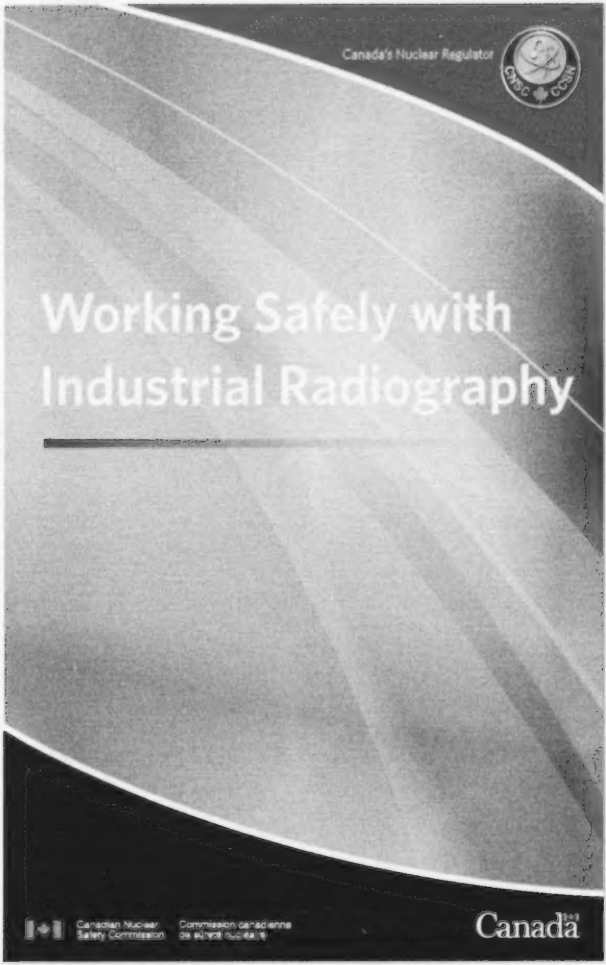
Canada's Nuclear Regulator
CNSC CCSN
Working Safely with Industrial Radiography
Canadian Nuclear Safety Commission
Commission canadienne de sûreté nucléaire
Canada

Working Safely with Industrial Radiography

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Working Safely with Industrial Radiography

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Introduction

This booklet contains guidelines on the safe handling and use of industrial radiography exposure devices, and provides background information about radiation to people working with or near these devices. It is not a substitute for regulatory requirements, nor does it relieve a person from complying with those requirements.

This publication is not intended to be the sole source of information for the purpose of training. Specific information and requirements are found in the operating manuals provided by manufacturers for each particular exposure device model, the *Nuclear Safety and Control Act* (NSCA) and applicable regulations, as well as in the licences issued by the Canadian Nuclear Safety Commission (CNSC).

Licensees are responsible for the development and implementation of specific operating procedures and an effective radiation protection program to comply with the NSCA and regulations.

Everyone can help keep the industrial radiography workplace safe by following standard operating procedures and security requirements, and by implementing effective radiation protection principles.

The role of the CNSC

- The CNSC is the federal agency responsible for regulating the nuclear industry in Canada.
- It regulates the use of nuclear substances and radiation devices to protect the health, safety and security of Canadians and the environment; and to implement Canada's international commitments on the peaceful use of nuclear energy.
- The CNSC enforces the NSCA and its regulations. It issues licences and certifies radiation devices and people.
- It continually monitors licensees to ensure compliance with regulatory requirements.
- All radiation devices used in Canada must be certified by the CNSC to ensure they are safe for use for their intended application.
- The CNSC also certifies exposure device operators to ensure that they are qualified to safely conduct industrial radiography.

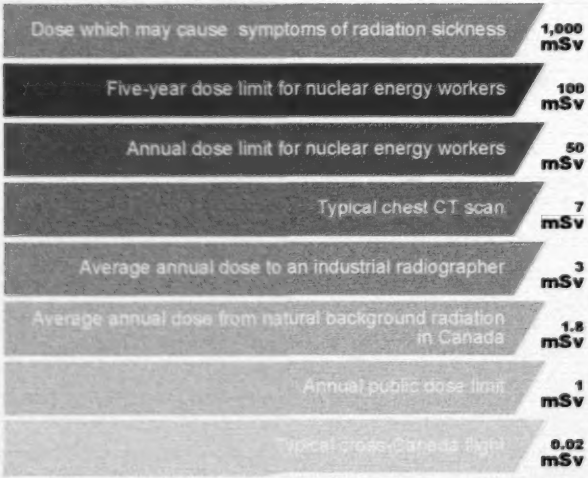
Industrial radiography

- Industrial radiography is a non-destructive method of looking for defects in materials, by examining the structures of welds, castings, and building components. Certified personnel use high-activity sealed radioactive sources of ionizing radiation in certified exposure devices.
- Two types of radiation are used in industrial radiography: X-rays and gamma sources (such as iridium-192, cobalt-60 and selenium-75).
- Industrial radiography is often carried out under difficult or adverse working environments.
- Accordingly, an exposure device is robust and designed to operate safely in Canada. Canadian certification of exposure devices requires them to operate over the broad temperature range of –40°C to 45°C.

What is radiation?

- Radiation is energy emitted by an atom or other body as it changes from a higher energy state to a lower energy state. Ionizing radiation, emitted from radioactive nuclear substances, is regulated by the CNSC.
- Natural background radiation is found in soil, rocks, food, air, building materials, cosmic rays, and our bodies. It contributes to about ¾ of our annual radiation exposure.

Radiation Dose Examples



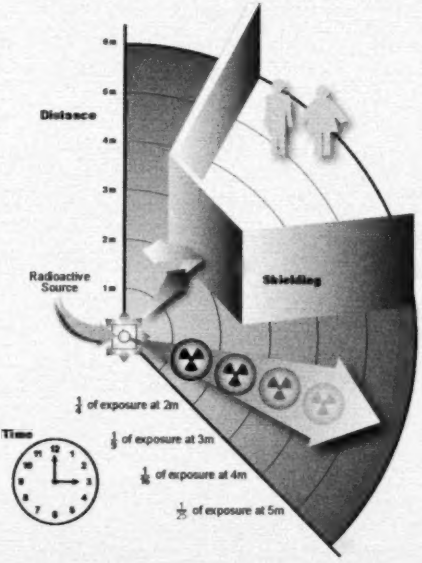
Radiation protection

The principles of radiation protection include:

Time - the shorter the time spent close to the source, the lower the radiation dose that will be received.

Distance - the intensity of radiation falls off sharply as a person moves farther away from the radioactive source.

Shielding - the thicker the protective material placed between the person and the source, the less the amount of radiation a person will receive.



Radiation safety officers

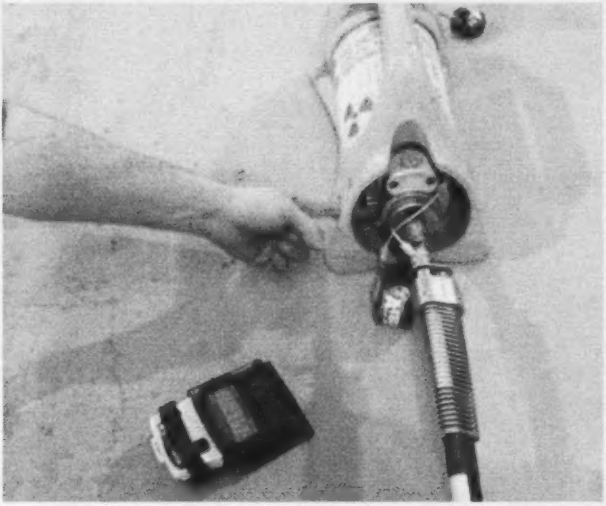
Radiation safety officers (RSOs) are designated by the licensee as persons responsible for being well-informed about radiation protection principles, methods and practices, as related to the licensed activity. The RSO is also responsible to effectively manage the radiation protection program.

The radiation safety officer is responsible for the effective management of the radiation protection program.

Responsibilities of industrial radiographers

- Industrial radiographers, such as Certified Exposure Device Operators (CEDOs) or trainees, are to ensure the safe conduct of their work, and comply with all applicable regulatory requirements.
- Their safety – as well as the safety of the public and the environment – depends at all times on a high degree of radiation safety practices.
- Industrial radiographers are responsible to follow the radiation protection program established by their employer, in accordance with regulatory requirements.
- In the often difficult and adverse working environments and weather conditions of industrial job sites, radiographers have to consider non-radiological hazards and wear appropriate personal protective equipment.
- Risks that may jeopardize the integrity, safety or security of exposure devices, radiography operations or radiation detection instruments have to be duly considered and mitigated.

Use and maintenance of radiography equipment



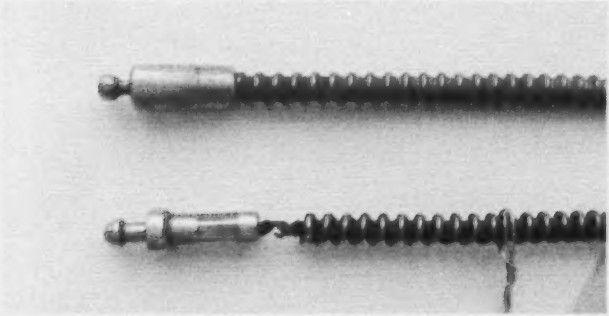
The use and maintenance of exposure devices is performed in accordance with the operating and maintenance instructions provided by the manufacturer of the exposure device, the licensee's radiation protection program and CNSC regulatory requirements.

- Regular routine maintenance of exposure devices is important to ensure their safe operation, including source return to shielded position and the functionality of locks, and must be carried out by trained and qualified personnel. Maintenance is limited to that

which constitutes routine operating procedures as indicated in the manufacturer's operating manual for the device.

- Exposure devices are leak-tested every 12 months, on both the sealed source and the shielding in accordance with regulatory requirements. Leak tests are conducted to detect a leakage of 200 Bq or less.
- Any exposure device that fails the leak test for either source or shielding (>200Bq) must be removed from use, and the CNSC must be immediately notified.
- The use and maintenance of exposure devices is performed in accordance with the operating and maintenance instructions provided by the manufacturer of the exposure device, the licensee's radiation protection program and regulatory requirements.
- Equipment must not be modified, abused or used for other purposes than those for which it is intended or designed.
- Any modification of an exposure device, or the use of unauthorized accessories or after market parts not in compliance with the approved design, will render the certificate invalid and are prohibited. Such changes could affect the safe operation of the device and lead to a serious accident or incident.

- Radiographers should identify any problems with exposure device equipment (such as the presence of rust or damage to a drive cable) and remove the affected items from service.



- Unusual events, accidents, incidents and defects in equipment are to be reported immediately to the licensee's radiation safety officer and the CNSC; if such problems are identified, discontinue use of the exposure device until such time that the defects have been addressed.

Use of source changers

- A source changer is a CNSC-certified transport package designed for source exchange purposes.
- Only certified exposure device operators – who have received the required training and specific written authorization from the licensee – can carry out source exchange operations using a source changer.
- Anyone carrying out a source change operation must specifically record their dosimeter reading for this activity.

Below are two different views of QSA 650L source changers used in Canada.

Top view of source changer with survey meter to the right.

Radiation safety monitoring equipment

Radiation monitoring equipment must be used to measure radiation doses. This equipment includes personal dosimeters, direct reading dosimeters, personal alarming dosimeters and radiation survey meters.

Personal dosimeters

- Personal dosimeters are passive dose-measuring equipment; the most commonly used being a thermoluminescent dosimeter (TLD) or an optically stimulated luminescence dosimeter (OSLD).

Images of a typical TLD (left), and a typical OSLD (right).

Direct reading dosimeters

- A direct reading dosimeter (DRD) is a real-time dosimeter that monitors the absorbed dose to the worker, and is checked periodically by the radiographer during the shift, to verify doses received during radiography work.

Note: these represent examples and are not the only types of dosimeters available in Canada

Personal alarming dosimeter

- A personal alarming dosimeter emits an audible warning signal when a dose rate alarm set point is exceeded.

Radiation survey meters

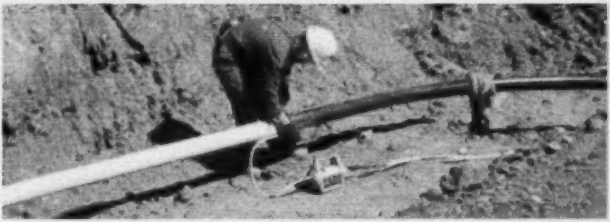
- A radiation survey meter measures the radiation dose rate. A radiation survey meter must be calibrated for the intended use.
- The calibrated survey meter is used to confirm appropriate positioning of radiation warning signs and barriers around the radiography work area.
- The survey meter is used to confirm the return of the source into the shielded position in the exposure device following each exposure.
- The survey meter is used to confirm the integrity of the exposure device shielding before transport or use.
- Radiation survey meters must be calibrated every 12 months.

Training requirements for industrial radiographers

All workers using exposure devices must successfully complete the required training program. This program, which may be a combination of external training and training by the licensee, should include:

- basic radiation safety information, including keeping doses as low as reasonably achievable (ALARA)
- review of licensee radiation safety program and regulatory requirements
- review of the licence and its conditions
- the importance of the use of barriers and signage
- specialized training for source recovery operations (for those expected to respond to emergency situations)
- radiation safety awareness training (particularly to workers who may work in the proximity of exposure devices)
- periodic refresher training is also recommended every three years

Certification requirements for industrial radiographers



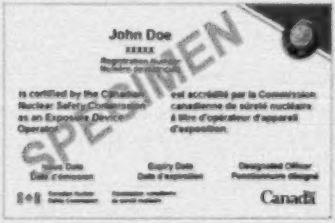
Industrial radiographers must be certified by the CNSC in order to operate exposure devices. The CEDO designation identifies those industrial radiographers with the knowledge, skills and abilities to:

- safely and securely handle exposure devices
- prepare exposure devices for transport
- store and operate industrial gamma radiography exposure devices and related accessories
- properly utilize radiation detection and monitoring equipment
- understand and comply with all relevant regulatory requirements found on the CNSC website nuclearsafety.gc.ca

Certified exposure device operators

In order to become a CEDO, the trainee is required to successfully complete a number of prerequisites, including:

- a pre-certification mathematics examination
- be of the age of majority (in the province where the work is performed) and be designated as a nuclear energy worker (NEW), if required
- successful completion of a 40 hour radiation safety training program
- accumulation of 320 hours of on-the-job training
- obtain a passing grade on the CEDO examination



Industrial radiographers must be certified by the CNSC to operate exposure devices.

Trainee supervisors

- Trainee supervisors are CEDOs who directly supervise and continuously observe the trainee during the operation of an exposure device. The trainee supervisor is expected to be close enough to ensure the safe operation of the device, the accessory equipment and radiation monitoring equipment.

Transportation of Dangerous Goods (TDG)

- Anyone who prepares a shipment of, or offers dangerous goods for transport must be trained in the proper handling and identification of Class 7 (radioactive material) shipments, in accordance with the *Transportation of Dangerous Goods Regulations*.
- It is the responsibility of the consignor, usually the licensee, to ensure that the carrier transporting the nuclear substance has fulfilled its requirements for training and radiation protection.

- A TDG certificate must be issued by the employer.

Example of a TDG certificate issued by an employer

TDG Certificate

Company Name

Holder's name

Company Address

The above named employee has been trained in all aspects of handling and transportation of Class 7 dangerous goods by road

SPECIMEN

TDG Date Trained: 2013-08-30

Certificate Expires on: 2018-08-30

Employer Signature

Employer Signature

Issue Date: 2013-08-30

Emergencies

- Industrial radiography incidents and accidents can result in workers and members of the public being unnecessarily exposed to radiation.
- Situations leading to a radiological hazard include loss of control of the radioactive source or exposure device, damage to the source or exposure device, and direct contact with the source.
- The radiography licensee has a set of emergency procedures in place, specialized equipment and a plan of action in case of an incident or damage to an exposure device. A person who is authorized to respond to an emergency, usually an RSO, has specialized training in the safety, regulatory and technical requirements for dealing with those situations, or is acting under the guidance of a person who has received the specialized training.
- The most serious radiation exposures occur when a worker fails to follow specific operating procedures, fails to use radiation detection equipment, and/or remains next to (or physically handles) the unshielded source assembly, or if the source assembly falls in the hands of a non-authorized person.

- If the source assembly is mishandled by the worker, or when it is in the possession of members of the public, dose rates can be high enough to cause localized overexposure in a matter of seconds or minutes, and can result in severe injury and even death.
- The licensee's emergency procedures should include information on actions to be taken, as well as immediate notification to the CNSC and local first responders.

Vehicle carrying exposure devices involved in a transport accident

If an accident occurs while an exposure device is being transported in a vehicle, a preliminary report shall immediately be made by the RSO to the CNSC, describing the location and circumstances of the accident and any action(s) taken or proposed to be taken as a result of the accident.

The area around an incident is controlled by:

- limiting, to the extent possible, the spread of any radioactive material
- restricting and posting the area accordingly and sending for assistance as required
- placing barriers, signs or personnel at every point of entry into the affected area to prevent entry by unauthorized persons
- recording the name, address and telephone number of anyone who may have been exposed to – or contaminated by – radioactive material, and request them to remain available for assessment by an expert in radiation protection
- planning radiographic source recovery, if necessary

If the survey meter is damaged, take it out of use. Assume that the radiographic source is fully unshielded; stop work until a fully operational and calibrated survey meter is available.

Specific examples of transport incidents may include, but are not limited to:

- a vehicle is involved in an accident
- the source is outside of the shielded position while being transported

Any other incidents or accidents involving the transport of nuclear substances and radiation devices must also be reported immediately to the CNSC.

The work area must be clear of all unauthorized persons.

Lost or stolen exposure device(s)

- A missing or stolen exposure device containing radioactive source(s) can be a significant hazard if found by members of the public unaware of the radiation danger. It is imperative that anyone working with an exposure device be aware of the security implications.
- Immediately report any lost or stolen exposure device or nuclear substance, or vehicle containing an exposure device or nuclear substance, to the CNSC by calling the CNSC Duty Officer at 613-995-0479.
- Immediately contact local law enforcement authorities to report the lost or stolen exposure device or other regulated equipment.

Daily tasks for industrial radiographers

Before you start:

All equipment selected for the job must be checked, verified to be in working order and documented.

- ☐ Are you familiar with the job site?
- ☐ Do you have a clear understanding of the nature of the work you are being asked to do?
- ☐ Has a hazards assessment been completed for this job – including discussion of the specific conditions of the job, such as start time, duration, site conditions, etc., – with both the client and your employer (licensee)?
- ☐ Do you have all the equipment needed for the job prior to transport?
- ☐ Did you check your emergency equipment before leaving?
- ☐ Do you have a calibrated and operational survey meter?
- ☐ Do you have the appropriate exposure device and equipment for the job at hand?
- ☐ Did you do your pre-operational checks on the exposure device and is it safe for transport?
- ☐ Do you have all the required documentation with you?

- ☐ Have you prepared the required shipping documentation?
- ☐ Have you checked (or confirmed) the dose rate on the surface of the exposure device?
- ☐ Has the exposure device been properly stored and secured inside the vehicle?
- ☐ Have you displayed all four Class 7 placards on the vehicle, if required?
- ☐ Have all TDG requirements been met to transport the exposure device to the job site?
- ☐ Do you have your valid TDG certificate with you?

During operations (at the job site):

Safety and security of people and the exposure device must be maintained at all times

- ☐ Have you installed radiation warning signs, proper signage and barriers at every point of access?
- ☐ Have you communicated with the client the requirements to do the job safely at the job site?
- ☐ Was all your equipment verified before starting (pre-operational checks), including personal alarming dosimeters and radiation survey meters?
- ☐ Have you verified that the work area is clear of all persons and the work start time has been communicated to both the client and other workers onsite?
- ☐ Is your radiation survey meter operational and are you using it?
- ☐ Have the radiation levels been monitored in the surrounding area and at the barriers?
- ☐ Are you monitoring the area for any unauthorized entry?

At the end of the job:

All required documentation must be completed and any unusual occurrences, safety or equipment concerns must be immediately reported.

- ☐ Have you used your radiation survey meter to check that the source is returned to its fully shielded position inside the exposure device?
- ☐ Have the radiation surveys been carried out?
- ☐ Is the device locked and secured?
- ☐ Did you communicate with the client once the job is done?
- ☐ Have you removed all barriers and warning signs that were posted?
- ☐ Have you completed all required documentation, including shipping documentation?
- ☐ Have you recorded your daily dose?
- ☐ Has the exposure device been securely returned to the storage location in the transport vehicle?
- ☐ Did you complete all the necessary verifications?
- ☐ Is the exposure device ready for transportation?
- ☐ Have all TDG requirements been met?
- ☐ Once back at the licensee location, has the exposure device been stored in a secure

enclosure that limits radiation exposure, restricts unauthorized access and is shielded from the public?

If you are uncertain about any of these checks, you must refer to your specific operating procedures, and/or contact your radiation safety officer before beginning work or at any time during your work.

Conclusion

Industrial radiography can present significant risks to the health and safety of the worker and other people nearby. That is why regulatory requirements are in place to ensure that this work can be done safely and minimize the risk to all involved. Following proper safety procedures, using effective radiation protection principles, and helping others to do likewise will ensure that the industrial radiography workplace remains safe at all times.

Relevant CNSC documentation

Nuclear Safety and Control Act

General Nuclear Safety and Control Regulations

Radiation Protection Regulations

Nuclear Substances and Radiation Devices Regulations

Packaging and Transport of Nuclear Substances Regulations

INFO-0742— *Proper Care and Use of Personal Dosimeters*

INFO-0744— *Guidelines for Handling Packages Containing Nuclear Substances*

G-129 rev.1— *Keeping Radiation Exposures and Doses "As Low as Reasonably Achievable"*

Glossary of terms

Alarming dosimeter
A small electronic instrument that can be worn by a person, which sounds an alarm when a high radiation dose rate is encountered or when a specific radiation dose rate has been exceeded. Often referred to as a personal alarming dosimeter (PAD).

As low as reasonably achievable (ALARA)
A principle of radiation protection, where exposures are kept as low as reasonably achievable, with social and economic factors taken into account.

Artificial radiation
The radioactive substances or sources of radiation, which are created by human intervention (e.g., gamma radiation from radiographic sources, medical X-rays).

Background radiation
Naturally occurring radiation, to which every living organism is continuously exposed.

Becquerel
An International System (IS) unit of activity, which is equal to one radioactive disintegration per second.

Canadian Nuclear Safety Commission (CNSC)
The CNSC is the federal agency responsible for regulating the nuclear industry in Canada.

Certified exposure device operator (CEDO)
A person certified by the CNSC, with the knowledge, skills and decision-making abilities necessary to safely operate an exposure device.

Dose
The radiation absorbed by the body.

Dosimeter
A dosimeter is an instrument that measures radiation doses. There are several types of personal dosimeters, such as thermoluminescent dosimeters (TLD), optically stimulated luminescent dosimeters (OSLD) and direct reading dosimeters (DRD).

Exposure device
A radiation device that is designed for carrying out radiography and includes any accessory to the device (including any sealed source assembly, shielding, drive mechanism, sealed assembly guide tube and exposure head).

Industrial radiography
Uses exposure devices containing sealed nuclear substances for non destructive testing. Sealed nuclear substances for crawler control may also be used.

Ionizing radiation
Radiation which ionizes atoms when it passes through matter (removing electrons), and is potentially dangerous to humans.

Leak tests
Tests performed to ensure that the sealed source is intact. Leak tests are carried out in accordance with CNSC regulations and expectations.

Licensee
A company or person to whom a CNSC licence has been issued for the possession and use of nuclear substances and radiation devices.

Non-destructive testing (NDT)
The testing or examination of an object, to verify that it is free from defects. Some examples include industrial radiography, ultrasonic testing, magnetic particle testing and dye-penetration testing.

Nuclear energy worker (NEW)
A nuclear energy worker is a person required to perform duties in such circumstances that there is a reasonable probability that they may receive a dose of radiation greater than the regulatory limit for the general public.

Operating procedures
The instructions supplied by the licensee covering radiation safety and regulatory requirements related to the use and possession of exposure devices.

Overexposure
A radiation dose (to a person) in excess of a regulatory limit.

Package
The complete product of the packing operation, consisting of the packaging and its contents prepared for transport. The types of packages are subject to activity limits and material restrictions, and must meet regulatory requirements.

Radiation safety officer (RSO)
A person designated by the licensee (Applicant Authority) to be responsible for the management and control of the radiation protection program.

Radiation survey meter
An instrument that is capable of measuring radiation dose rates (μSv/h or mSv/h), but not contamination.

Radioisotope
A radioactive element or form of element, either artificially-occurring or naturally-occurring.

Shielding
Materials placed around a radiation source, for the purpose of reducing radiation levels.

Sievert
The metric unit used for measuring a radiation dose. 1 Sievert = 100 rem

Source changer
A certified transport package, designed specifically for source exchange purposes.

Trainee
An individual undergoing training, who is authorized by a licensee to operate an exposure device under the immediate supervision of a designated trainee supervisor.

Trainee supervisor
A certified exposure device operator (CEDO), who has the qualifications, training and experience necessary to supervise a trainee during the operation of an exposure device. The trainee supervisor is appointed by the licensee.

Transport
The overall activities of handling, carrying, storing, transiting and receiving at the final destination, of packages containing radioactive sources. Transport includes normal and accident conditions encountered during any of these activities.

Conversion factors for International System (SI) units

These tables give the most commonly used ranges.

RAD (rad) replaced by the GRAY (Gy)

1 kilorad (krad)	= 10 gray (Gy)
1 rad (rad)	= 10 milligray (mGy)
1 millirad (mrad)	= 10 microgray (µGy)
1 microrad (µrad)	= 10 nanogray (nGy)

GRAY (Gy) replaces the RAD (rad)

1 gray (Gy)	= 100 rad (rad)
1 milligray (mGy)	= 100 millirad (mrad)
1 microgray (µGy)	= 100 microrad (µrad)
1 nanogray (nGy)	= 100 nanorad (nrad)

ROENTGEN (R) replaced by the COULOMB/kg (C/kg)

1 kiloroentgen (kR)	= 258 millicoulomb/kg (mC/kg)
1 roentgen (R)	= 258 microcoulomb/kg (µC/kg)
1 milliroentgen (mR)	= 258 nanocoulomb/kg (nC/kg)
1 microroentgen (µR)	= 258 picocoulomb/kg (pC/kg)

COULOMB/kg (C/kg) replaces the ROENTGEN (R)

1 coulomb/kg (C/kg)	= 3876 roentgen (R)
1 millicoulomb/kg (mC/kg)	= 3876 milliroentgen (mR)
1 microcoulomb/kg (µC/kg)	= 3876 microroentgen (µR)
1 picocoulomb/kg (pC/kg)	= 3876 nanoroentgen (nR)

REM (rem) replaced by the SIEVERT (Sv)

1 kilorem (krem)	= 10 sievert (Sv)
1 rem (rem)	= 10 millisievert (mSv)
1 millirem (mrem)	= 10 microsievert (μSv)
1 microrem (μrem)	= 10 nanosievert (nSv)

SIEVERT (Sv) replaces the REM (rem)

1 sievert (Sv)	= 100 rem (rem)
1 millisievert (mSv)	= 100 millirem (mrem)
1 microsievert (μSv)	= 100 microrem (μrem)
1 nanosievert (nSv)	= 100 nanorem (nrem)

CURIE (Ci) replaced by the BECQUEREL (Bq)

1 kilocurie (kCi)	= 37 terabecquerel (TBq)
1 curie (Ci)	= 37 gigabecquerel (GBq)
1 millicurie	= 37 megabecquerel (MBq)
1 microcurie	= 37 kilobecquerel (kBq)
1 nanocurie	= 37 becquerel (Bq)
1 picocurie	= 37 millibecquerel (mBq)

BECQUEREL (Bq)* replaces the CURIE (Ci)

1 terabecquerel (TBq)	= 27 curie (Ci)
1 gigabecquerel (GBq)	= 27 millicurie
1 megabecquerel (MBq)	= 27 microcurie
1 kilobecquerel (kBq)	= 27 nanocurie
1 becquerel (Bq)	= 27 picocurie

*1 Bq = 1 disintegration per second (s^{-1})